2016-21TS
Published August 2016

LRRB
LOCAL
ROAD RESEARCH
BOARD

TECHNICAL SUMMARY

Technical Liaison:
Lyndon Robjent,
Carver County Public Works
LRobjent@co.carver.mn.us

Project Coordinator:
Bruce Holdhusen, MnDOT
Bruce.Holdhusen@state.mn.us

Principal Investigator:
Daniel Wegman, Braun Intertec

LRRB PROJECT COST:
$67,740

CIR involves pulverizing a surface layer of pavement and mixing it with an emulsion to create a new layer of asphalt.

RESEARCH SERVICES & LIBRARY
OFFICE OF TRANSPORTATION SYSTEM MANAGEMENT

Testing Cracking Resistance in Cold In-Place Recycling Mixes

Fracture mechanics tests can assist the development of improved CIR designs and provide better quality assurance and quality control in the field, reducing costs and increasing performance.

What Was the Need?

As asphalt pavements age, they are susceptible to cracking and other forms of deterioration caused by traffic and weather conditions. To mitigate these effects, MnDOT designs asphalt mixes to resist deterioration as long as possible, and repairs them when necessary with low-cost rehabilitation measures.

Cold in-place recycling (CIR) is one cost-effective rehabilitation method. CIR involves pulverizing part of the surface layer of a pavement, crushing it into an aggregate with the desired gradation, mixing it with a binding agent such as emulsified asphalt, and placing and compacting this mixture over the remaining portion of the original pavement layer. All of these processes are performed in the field by a train of vehicles moving along the pavement. Where typical hot-mix asphalt (HMA) involves mixing aggregates and binders at high temperatures, CIR involves mixing at ambient temperatures in the field.

To ensure that CIR mixtures perform well, they are—like HMA mixtures—subjected to laboratory tests that predict their resistance to cracking and other deterioration in the field. However, the use of recycled asphalt can make it difficult to accurately evaluate CIR mixtures. Research was needed into nontraditional tests that might be more suitable than traditional tests for assessing the fracture mechanics (that is, the susceptibility to cracking) of materials used in CIR mixtures.

What Was Our Goal?

The purpose of this project was to validate the effectiveness of two fracture mechanics tests in evaluating the performance of CIR mixtures: the semicircular bend (SCB) test and the disk-shaped compact tension (DCT) test. These tests involve notching a sample specimen, subjecting it to a load and measuring the way cracks propagate in the material. The DCT employs a disk-shaped specimen with pinholes on either side of its notch, used to pull each side of the disk in opposite directions perpendicular to the notch. The SCB uses half a disk and applies forces in opposite directions, parallel to the notch.

What Did We Do?

Researchers began by creating CIR specimens on which to perform the DCT and SCB tests. They took core samples from different roadways in Carver County, Minnesota, and crushed them into an aggregate to be used in CIR mixtures. Researchers blended the aggregates from these cores together to minimize any variability in material properties among specimens. They then used a mechanical mixer to blend aggregate from the crushed cores with various kinds of binder at room temperature, using four different mix designs. The binders comprised three types of asphalt emulsion and a foamed asphalt. Researchers also compacted these specimens at room temperature using laboratory equipment.

Then they conducted DCT and SCB tests on these samples and compared results. The tests were conducted at several laboratories in order to evaluate any variability in results from using different equipment on similar samples. To simplify SCB testing, researchers

continued

"We're trying to develop a test that will allow us to predict the performance of CIR pavements in the same way we do with HMA. That's very hard to do right now."

—Lyndon Robjent,
Division Director/County Engineer, Carver County Public Works

"The SCB represents an opportunity to implement a more practical CIR test that will ultimately reduce the cost of mix design and allow for relatively easy correlation of the design with performance in the field."

—Daniel Wegman,
Principal Engineer, Braun Intertec

Produced by CTC & Associates for:
Minnesota Department of Transportation
Research Services & Library
MS 330, First Floor
395 John Ireland Blvd.
St. Paul, MN 55155-1899
651-366-3780
www.mndot.gov/research

The SCB test evaluates the propagation of cracks in a notched semicircular sample as it is subjected to loads.

developed a variation of it that uses a new fracture energy index called Fracture Index Value for Energy (FIVE), instead of measuring fracture energy directly.

What Did We Learn?

Researchers found that SCB FIVE is a viable option for characterizing the behavior of CIR materials. The test shows great potential for use in developing performance specifications for CIR mix designs and for use in field testing for quality assurance and quality control on CIR projects. Based on their analysis of test results with four mix designs, researchers suggested a minimum SCB FIVE index value that CIR mixtures should meet.

There was more variability in SCB FIVE results among different laboratories than in DCT test results, and one laboratory showed consistently higher values, probably due to differences in equipment. However, SCB FIVE testing was able to differentiate and rank the expected performance of CIR mixtures in a way similar to DCT tests, suggesting it adequately evaluates the fracture performance of CIR materials. Further, SCB FIVE samples require less material and time to prepare than DCT samples. DCT test samples also tend to fail around the pinholes used to apply loads, so the test may be impractical for specimens that have 100 percent recycled materials.

What's Next?

MnDOT will continue to evaluate the use of the SCB and other laboratory tests for evaluating CIR mixtures. Researchers recommend collecting more data on SCB FIVE testing by using it routinely on MnDOT CIR mixtures. They also suggest monitoring CIR pavement test sections to compare field performance with SCB FIVE results and conducting further research on variability in test results among different laboratory equipment.

This Technical Summary pertains to the LRRB-produced Report 2016-21, "Optimizing Cold In-Place Recycling (CIR) Applications Through Fracture Energy Performance Testing," published June 2016. The full report can be accessed at mndot.gov/research/TS/2016/201621.pdf.